Radish

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Scientific Name and Introduction: The radish, *Raphanus sativus*, is a member of the Cruciferae family, native to Europe or Asia. It was once grown on a small scale in all areas of the U.S. and also as a greenhouse vegetable. However, mechanization of harvesting and handling has resulted in more centralized production. The word raphanus comes from the Greek word meaning quick appearing or easily grown. The roots are of many shapes, sizes and colors; eg., round, turnip-shaped, oval, olive shaped, half-long or long. Color varies from white, pink-red, purple, yellow or even black. However, the most common radish is oval with a dark red skin and white flesh (Thompson and Kelly, 1957; Maynard and Hochmuth, 1997).

Quality Characteristics and Criteria: Radishes should be fresh, well-colored, tender, firm, crisp, smooth with no ridges, free from dirt or other foreign material, and free from harvest cuts, abrasions and insect damage. They should not be stringy or woody, soft, flabby, or wilted. Bunched radishes should have fully intact tops that are dark-green with no yellowing; they may be slightly wilted. Size varies depending on market demand, but larger roots are more likely to be pithy (Carione and Lucas, 1972; USDA, 1975; Thompson and Kelly, 1957).

Horticultural Maturity Indices: Harvest maturity is based on size and market demand. The diameter of oval types should be between 2 and 3 cm (0.75 to 1.25 in). Bunched radishes are harvested in either regular or big bunch size, and roots for cello packages are pulled at regular or jumbo size (Nonnecke, 1989).

Grades, Sizes and Packaging: There are two USDA grades for topped and bunched radishes: U.S. No. 1 and U.S. Commercial. Bunched radishes have full-length tops tied in bunches, while topped radishes have clipped tops no more than 1 cm (0.38 in) long. Root diameters are termed: Small, 1.9 cm (0.75 in); Medium, 1.9 to 2.5 cm (0.75 to 1.0 in); Large 2.5 to 3.2 cm (1 to 1.25 in); and Very Large 3.2 cm (over 1.25 in). U.S. No.1 roots have similar varietal characteristics and are clean, well formed, smooth, firm, and tender. They are also free from decay, cuts, pithiness, or disease, and from damage caused by freezing, growth cracks, insects or other means. Bunched radishes have tops that are fresh and free from decay and damage caused by freezing, seed stem, yellowing or other discoloration, diseases, insects or other means. In order to allow for variation in grading and handling, a 5 to 10% variation by count, are acceptable tolerances for a U.S. No. 1 grade product. If the variation > 10 but < 20%, they are designated U.S. Commercial (USDA, 1968; Maynard and Hochmuth, 1997).

Radishes are available in many size containers. Topped radishes are packed in 168 g (6 oz) 224 g (8 oz), 454 g (1 lb), 2.3 kg (5 lb), 11 kg (25 lb) and 18 kg (40 lb) perforated plastic bags. Commonly, thirty 168 g (6 oz), twenty-four 224 g (8 oz), or fourteen 454 g (1 lb) bags are boxed together for retail, while 11 kg (25 lb) bags are used for the foodservice industry (Buurma, 1999).

Radishes are first graded according to diameter to eliminate spikes (< 1.9 cm; 0.75 in) and to accumulate Jumbo's (> 3.8 cm, 1.25 in). The radishes are then conveyed over grading tables to remove products below acceptable grade standards. After being graded, cellos are packaged using vertical form fill machines. These machines form the breathable poly bag, weigh the specific amount of desired radishes, seal the bag or provide a zipper locking system. These bags are then hand-packed into wax cartons and temporarily stored at 2.2 °C (36 °F) before shipment.

Pre-cooling Conditions: Hydro-cooling at 0 to 4.5 °C (32 to 40 °F) is the preferred method of pre-cooling. Cello packs are hydro-cooled to restore crispness, bulk stored in bins, and then placed in refrigerated coolers prior to grading. Bunched radishes are dipped in chlorinated water at 2.2 °C (26 °F), to restore crispness and freshness to the tops and roots, as well as to remove field debris. They are then packed into cartons, usually 24 bunches per carton, hydro-cooled and the carton topped with an ice slurry before shipping (Ryall and Lipton,1972b; Brooker and Pearson, 1970).

Optimum Storage Conditions: Topped radishes can be held 3 to 4 weeks at 0 °C (32 °F) with 90 to 95% RH, and at least 7 days at 7.2 °C (45 °F). Bunch radishes are harder to keep fresh due to the perishability of the tops. However, they can be held at 0 °C (32 °F) and 90 to 95% RH for 1 to 2 weeks. Winter or black radishes can be stored under the same conditions for 2 to 4 mo. Addition of top ice aids in keeping the tops fresh (Ryall and Lipton, 1972a).

Controlled Atmosphere (CA) Conditions: A 1 to 2% O_2 + 2 to 3% CO_2 CA at 0 to 5 °C (32 to 41 °F) slightly extends storage-life (Ryall and Lipton, 1972b; Saltveit, 1997).

Retail Outlet Display Considerations: Packaged radishes should be placed in a refrigerated rack. Bunch radishes should be refrigerated, and can be iced or misted to help preserve quality.

Chilling Sensitivity: Radishes are not sensitive; store as cold as possible without freezing.

Ethylene Production and Sensitivity: Radishes produce small amounts of ethylene and are not particularly sensitive to ethylene exposure.

Respiration Rates:

	Topped Roots	*Bunched Roots with Tops*
Temperature	(mg CO_2 kg^{-1} h^{-1})	
0 °C	14 to 17	3 to 9
4 to 5 °C	19 to 21	6 to 13
10 °C	31 to 36	15 to 16
15 to 16 °C	70 to 78	22 to 42
20 to 21 °C	124 to 136	44 to 58
25 to 27 °C	158 to 193	60 to 89

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day. Data are from Hardenburg et al., 1986.

Physiological Disorders: Freezing injury can cause softening and shriveling, and leakage of pigment for red radishes. Growth cracks or air cracks reduce quality when they are > 6 mm (0.25 in) deep and associated with discolored tissue. Over-maturity or stress during growth can induce dry, cottony voids in roots called pithiness. Yellowing of tops can result from over-maturity or exposure to ethylene or elevated storage temperature (Murry,1977; Nonnecke,1989).

Postharvest Pathology: The initial lesions of bacterial black spot (*Xanthomonas vesicatoria*) are brown and have a diameter of 1.0 to 2.5 mm (0.04 to 0.1 in). They eventually turn black and coalesce. Protective measures include washing in water with 100 to 200 ppm of chlorine. Downy mildew (*Peronospora parasitica*) produces purplish-red to brown surface lesions that become rough and cracked in advanced cases, while the internal tissue can become grayish brown to black. Rhizoctonia root rot (*Rhizoctonia solani*) produces lesions that are initially round and light brown, and that can become

slightly sunken. The tissue can become spongy. This disease favors high RH. Avoid bruising, hydro-cool to 4.4 °C (40 °F) and store at 0 to 1.7 °C (32 to 35 °F) to control these diseases (Ryall and Lipton, 1972b).

Quarantine Issues: None

Suitability as Fresh-cut Product: Currently radishes are cut or diced in packaged salad mixes, and for foodservice, particularly for incorporation into salad bars.

Special Considerations: None

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